BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

As rescanning documents *will not* correct images, please do not report the images to the Image Problem Mailbox.

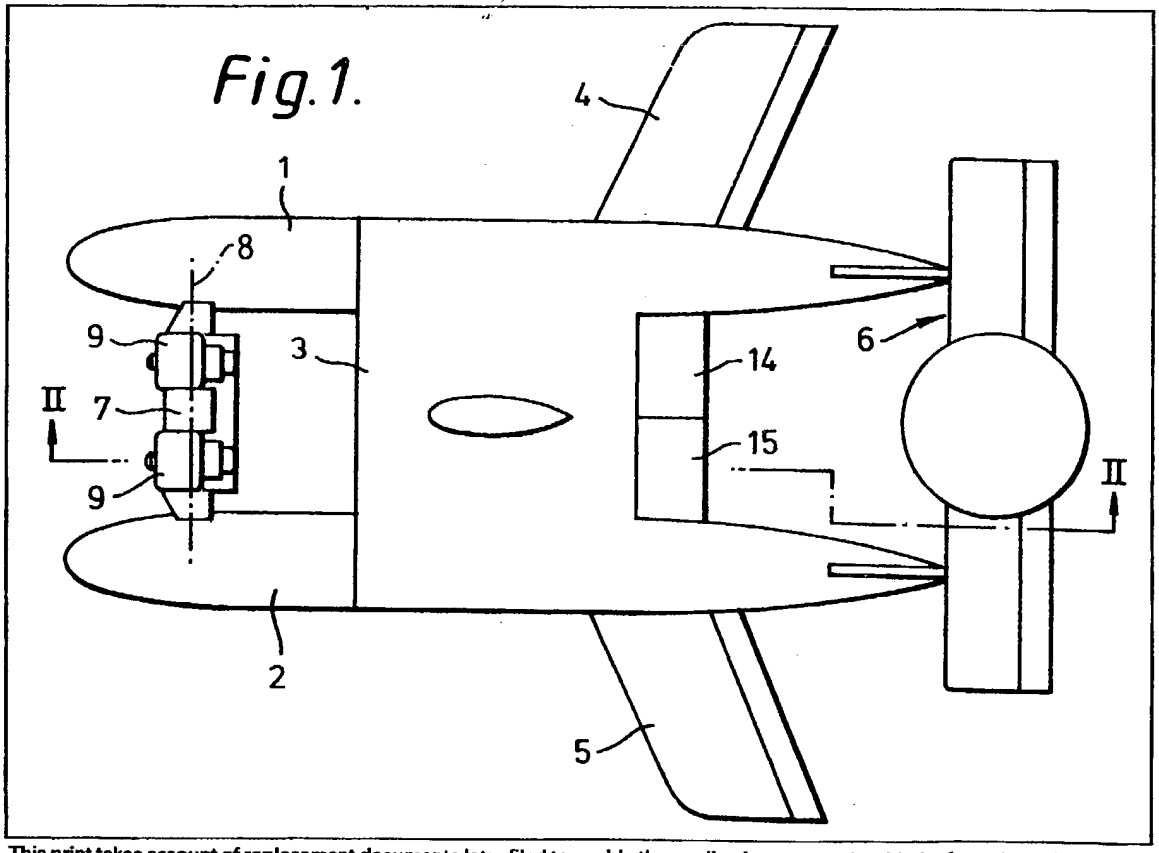
(12) UK Patent Application (19) GB (11) 2 120 990 A

(21) Application No 8314092
(22) Date of filing 20 May 1983
(30) Priority data
(31) 821785
(32) 28 May 1982
(33) Norway (NO)
(43) Application published 14 Dec 1983
(51) INT CL³ B60V 1/08 3/08
(52) Domestic classification B7K B DB B7W 3AX 3C3A 3E
(56) Documents cited None
(58) Field of search B7K B7A
(71) Applicants Paul Kjolseth, Rilstoppen 4, N-2007 Kjeller, Norway. Rolf Jan Mowill, Rugdeveien 7, N-Oslo 3, Norway.

(72) Inventors Paul Kjolseth, Rolf Jan Mowill.
(74) Agent and/or Address for Service Reddie and Grose, 16 Theobalds Road, London WC1X 8PL.

(54) Ground effect vehicle or aerofoil boat

(57) A ground effect or aerofoil boat has two parallel hulls (1,2) connected by a centre wing (3), a forwardly open space being formed below the centre wing between the hulls, and a tail structure (6). Two turbofan engines (9) are positioned in front of the centre wing (3) and are tiltable about a horizontal transverse axis, so that during take off and landing the slip stream from the engines can be directed below the centre wing, whereas during cruising it will sweep along the upper side of the centre wing to increase the aerodynamic lift. Each hull (1,2) is shaped with a sharp keel portion (10) aligned with the inner side of the hull. Side wings (4,5) are positioned further astern on the hulls than the centre wing to compensate for the shifting of the centre of lift of the centre wing during transition from cruising on water to a free flight a few meters above the water surface. Flaps (14,15) on the centre wing can serve as low-speed ailerons. A canard surface just below and behind the engine fan casings provides rapid lift control.



GB 2 120 990 A

This print takes account of replacement documents later filed to enable the application to comply with the formal requirements of the Patents Rules 1978 or 1982.

Fig.1.

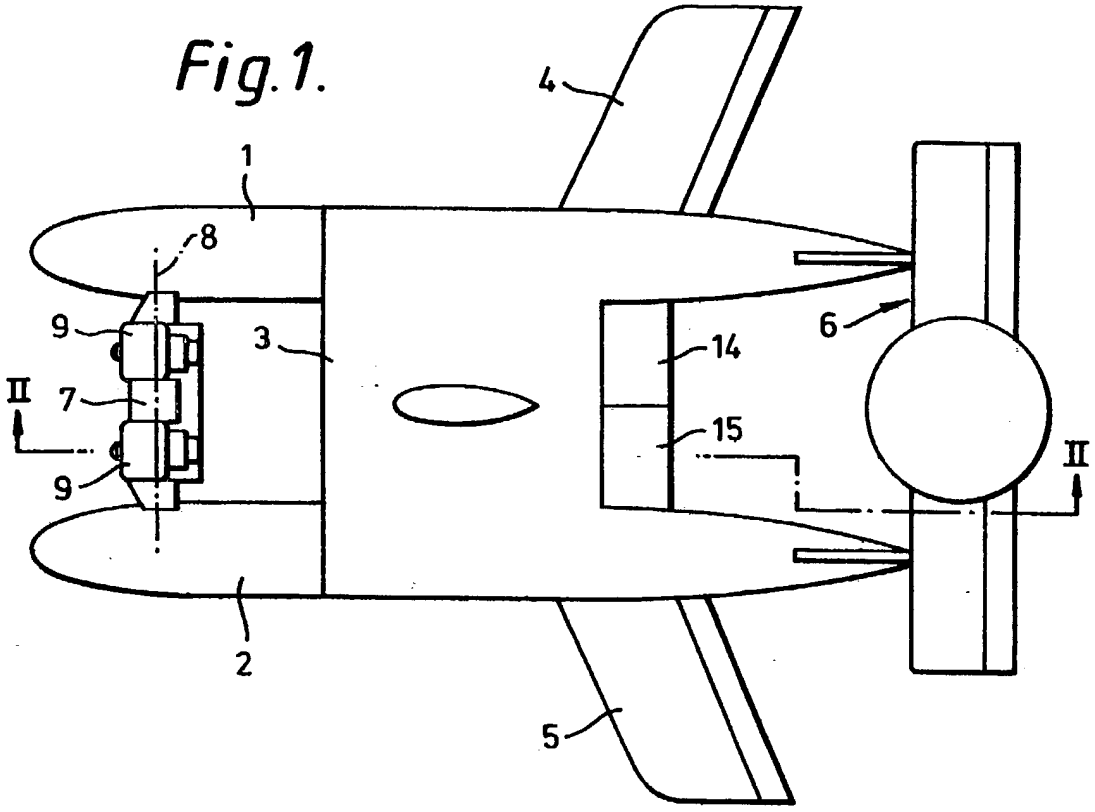
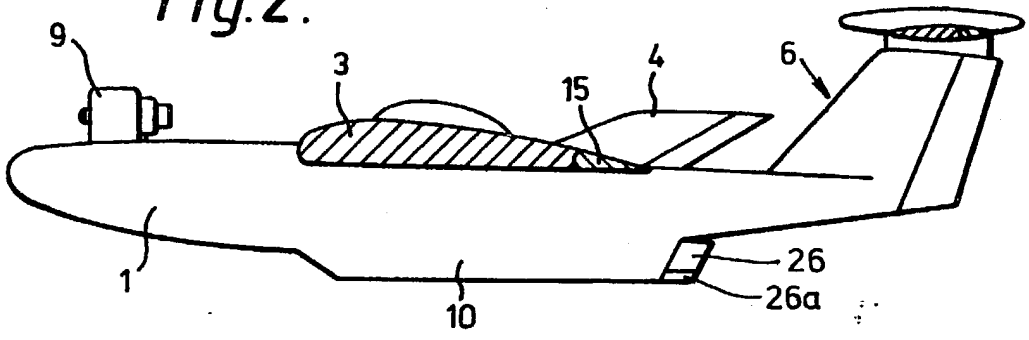


Fig.2.



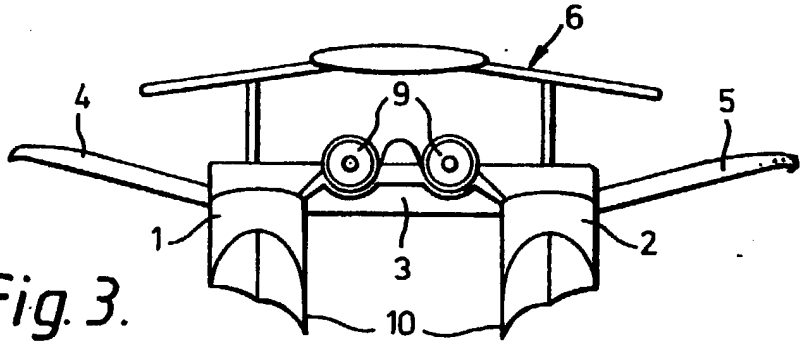


Fig.3.

Fig.4.

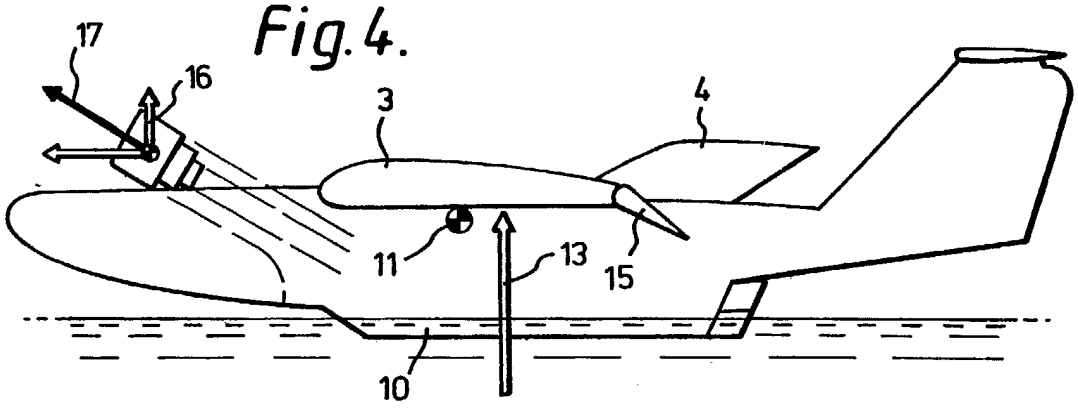


Fig.5.

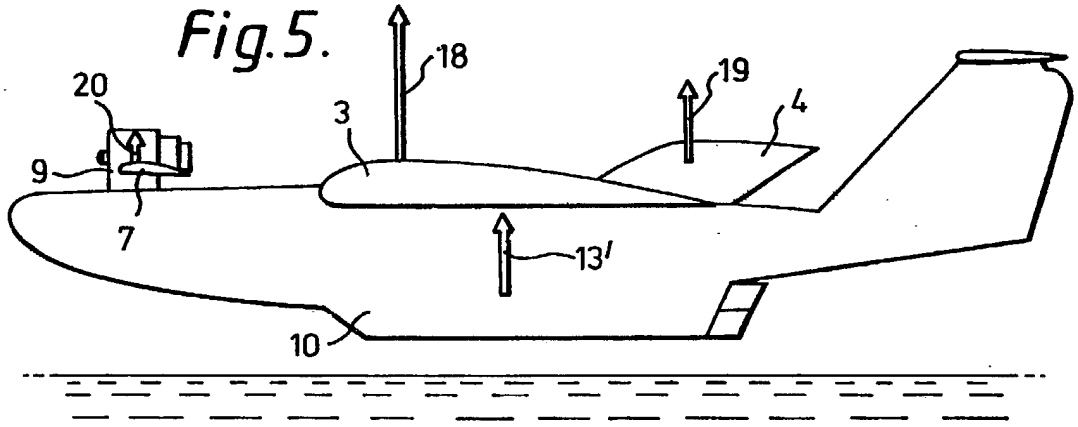


Fig.6.

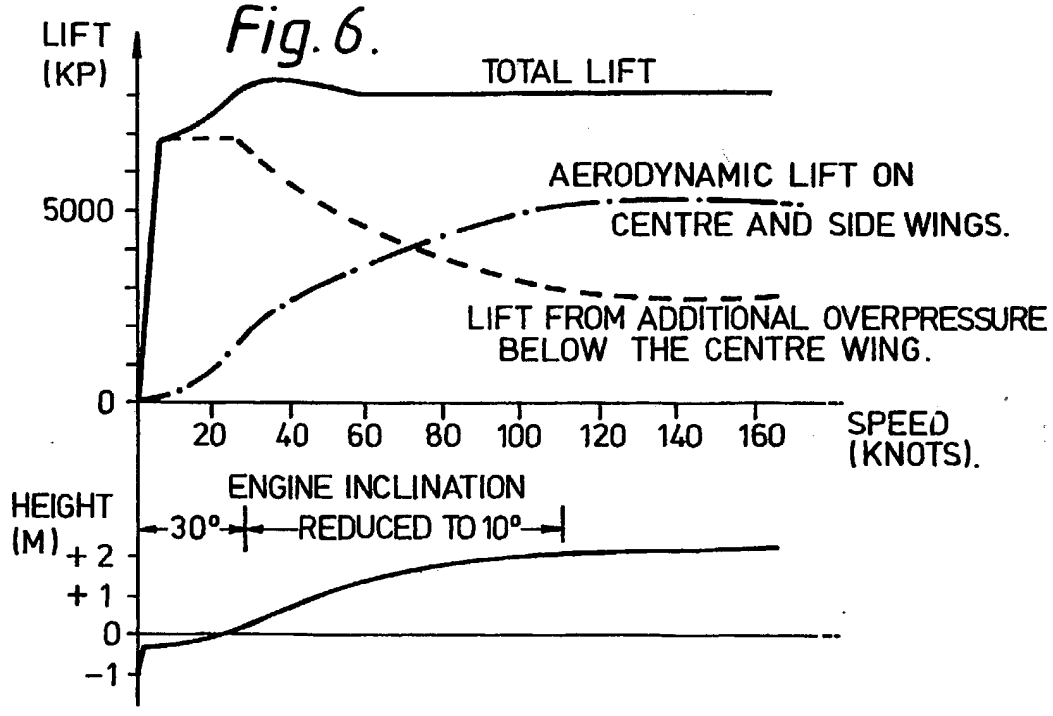


Fig. 7.

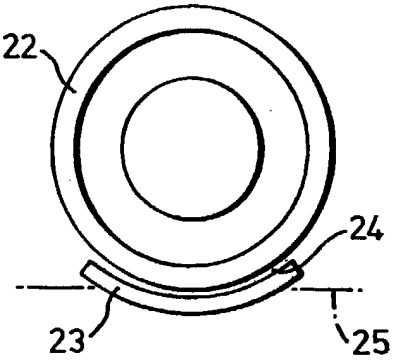
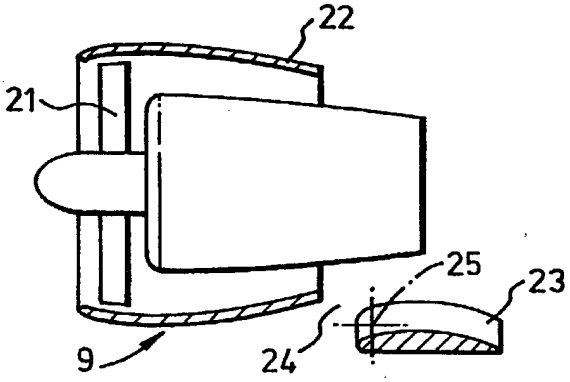


Fig. 8.



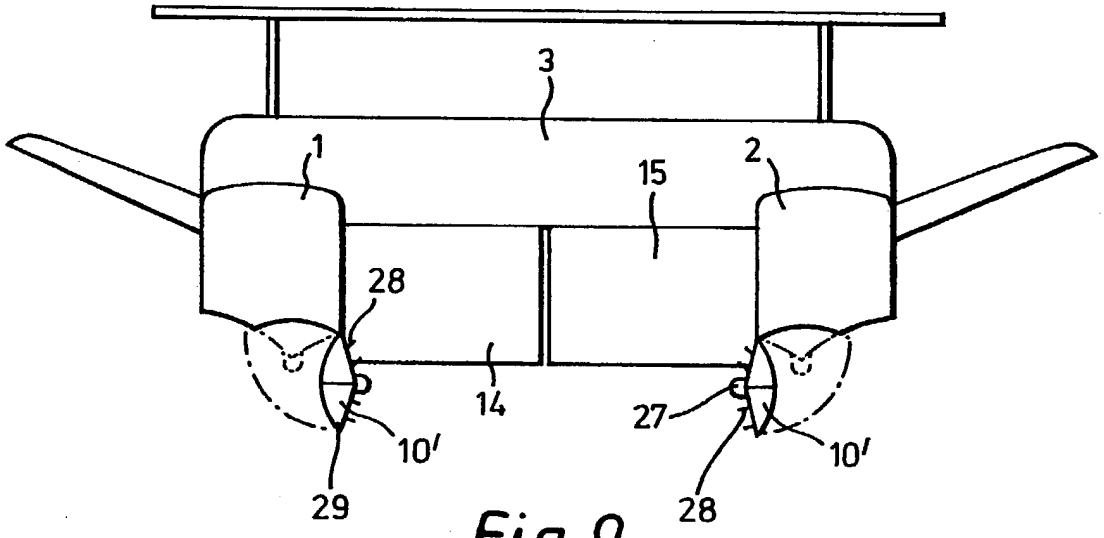


Fig. 9.

SPECIFICATION

Ground effect vehicle or aerofoil boat

The invention relates to a ground effect vehicle or an aerofoil boat having two parallel hulls, a center wing connecting the two hulls, a forwardly open space being formed below the center wing between the hulls, a tail structure connecting the hulls rearwardly of the center wing, and side wings positioned sufficiently far astern for their centers or lift to lie rearwardly of the center of lift of the center wing due to an over-pressure on the lower side thereof.

In connection with ground effect vehicles there exists a substantial problem in that the center of lift shifts drastically in the longitudinal direction of the vehicle dependent upon the height above the ground. At low speed and a very short distance to the ground a substantial part of the lift is created due to pressure against the lower side of the wing, and the point of action lies close to the center of the wing cord. When the speed and height increase, the center of lift shifts forwardly and lies approximately 0,25 · the length of the cord behind the leading edge of the wing. In other words, the vehicle is unstable about a horizontal transversal axis during a transition phase between low and greater height and low and high speed. It is therefore considered that such a vehicle must have an artificial stabilization by means of gyrocontrolled elevators, which is a complicated an vulnerable system.

The problem is referred to in US patent specification 3.661.111, which described an aerofoil boat of the type referred to above. The boat has a water propeller propulsion, and the center wing as well as the side wings are supposed to lie very close to the water surface. In order to prevent that the aerodynamic lift on the center wing shall lift the front of the vehicle too strongly as the speed increases, the aerodynamic lift on the upper side of the center wing is intentionally destroyed. In contrast therewith the vehicle according to the invention is designed to be able to operate also in heavy sea and generally foul waters, and the propulsion is to take place by means of one or more engines having a fan or an air propeller. The speed of such a vehicle is several times that which is possible by propulsion with a water propeller, and it is intended to utilize the speed to lift the vehicle out of the water and even out of the ground effect area, whereby it becomes possible to avoid high waves, holms, skerries etc.

In the design of such a vehicle there are several problems. Thus, it is not simple to provide sufficient lift at low speed and maintain this lift until the vehicle has lifted substantially, so as to make it possible to operate in heavy sea and generally foul waters. The control of the vehicle about all axes, first and foremost the horizontal transversal axis, constitutes a further problem as already mentioned. There is partly a question of compensating for the fact that the aerodynamic center of lift of a wing lies forward of the center of lift due to overpressure on the lower side. There is relatively ample time to effect this control, since the stability changes primarily with variations in speed and height. However, also a detailed control is required in order to correct instability due to fast acting influences, such as impact of waves. It is also important to provide a good control of the vehicle at low speeds. This is especially important in narrow waters.

The operative height of the vehicle according to the invention normally varies from a floating position to a few meters above the water surface, but it should be possible for a short period to rise to about 20-30 m above the water surface for special purposes,

From US patent specification 4.151.893 it is known to produce an accumulation of pressure below a wing by directing the efflux from a jet engine to under the wing, the outer ends of which are limited by end plates in order to prevent loss of pressure at the wing tips. The trailing edge of the wing has flaps preventing the air stream from escaping freely to the rear.

The vehicle according to the invention possesses the desired properties at both low and high speeds and is easily controlled. This is due to a combination of structural features which are stated in the main claim. Specifically, the following features are involved:

(a) At its trailing edge the center wing has wing flaps which can close the space below the wing at the trailing edge, at least partially.

(b) One or more engines having an air propeller or a fan are positioned so as to direct the slip stream from the engines into said forwardly open space to provide an overpressure therein,

(c) Each hull is shaped with a sharp keel portion of a sufficiently large vertical extent to keep the said space closed laterally until the vehicle has picked up sufficient speed to provide a substantially aerodynamic lift on the center wing as well as the side wings.

(d) The side wings are positioned well above the water surface so as to provide mainly aerodynamic lift and only a small ground effect.

In connection with each fan or propeller engine there is preferably provided a curved airfoil below the slip stream of the fan or the propeller to induce a secondary air stream on the upper side of the airfoil and produce an upwardly directed aerodynamic force varying with the position of the airfoil with respect to the slip stream, so that the position of this airfoil can be used to control the vehicle about its horizontal transversal axis.

Also the center wing should be positioned well above the sea level to permit the vehicle to operate in heavy sea. Preferably, the distance of the center wing (and also the side wings) from the sea level should be at least 1/6 of the centre wing chord when the vehicle is floating on calm sea.

The engine fans or propellers can be provided in ducts leading from the leading edge of the center wing to the lower side thereof. However, the fans or propellers are preferably positioned between the hulls forwardly of the center wind and mounted so as to be tiltable about a horizontal transversal axis from a position in which the slip stream from the engines is directed towards the forward opening into said forwardly open space to provide an overpressure therein, and in which the thrust force of the

engines has a substantial upwardly directed component, to a position in which the slip stream sweeps along the upper side of the center wing to increase the aerodynamic lift.

The engines are preferably stationarily mounted on a canard wing which is provided between the front portions of the hulls and is tiltable about an horizontal transversal axis.

The side wings may form part of the tail structure, thereby being out of the way, permitting the vehicle to berth without substantial risk of damping the side wings. It is nevertheless preferred to position the side wings on the outer side of each hull.

In order that the draft of the keel portions shall not be too large in the floating position of the vehicle, thereby preventing operations in shallow waters, each keel portion may be pivotally hinged about a longitudinal horizontal axis for folding up when the vehicle is in a floating position. Such a folding up can be automatic if the keel portions comprise floats. The keel portions may preferably be lockable in the folded up position, and they can carry wheels for wheeling the vehicle on solid ground when the keel portions are folded up.

The invention will now be further described by way of example with reference to the drawings, in which :

Figure 1 is a plan view of a ground effect vehicle according to the invention.

Figure 2 is a sectional view along the line II-II in Figure 1.

Figure 3 illustrates the vehicle of Figures 1 and 2 viewed from the front.

Figures 4 and *5* diagrammatically illustrate the forces acting on the vehicle at low speed and in normal cruising position, respectively.

Figure 6 illustrates lift and height as functions of the speed.

Figures 7 and *8* diagrammatically illustrate the principle of the control airfoils used in connection with the slip stream from the fan or propeller for rapid control of the vehicle about the horizontal transversal axis.

Figure 9 diagrammatically illustrates an embodiment having foldable keel portions.

The vehicle according to the invention shown in Figures 1 to 3 comprises two parallel hulls 1 and 2, respectively, a center wing 3 connecting the two hulls, two side wings 4 and 5, respectively, and a tail structure 6 connecting the rear ends of the two hulls 1 and 2. The vehicle further has a canard wing 7 between the front portions of the hulls 1, 2. This canard wing is tiltable about an horizontal axis extending transversely of the vehicle. The wing 7 carries two turbo-fan engines 9 which are stationarily mounted on the canard wing 7 and consequently tilt therewith. The wing and the engines can preferably tilt between a horizontal position shown in Figure 5 and the position shown in Figure 4, in which the engines are tilted approximately 30°. In the latter position, which is used during the take off and landing phases, the slip stream blows under the center wing 3 and produces an over-pressure below the center wing providing upwards of 80% of the total lift required. In addition to this lift the thrust of the engines also provide a direct lift because of the vertical component of the thrust force. Thereby, the vehicle will lift in the water approximately to the position illustrated in Figure 3. In this position only relatively thin keel portions 10 extending along the inner side of each hull 1, 2 dip into the water in order to close the space below the center wing 3 laterally and thereby prevent undesired loss of overpressure. Otherwise, each hull is approximately symmetric about a longitudinal center plane in order to reduce the forces on the vehicle.

The center of gravity of the vehicle is indicated at 11. The arrow 13 illustrates the resulting force due to the overpressure built up on the lower side of the wing 3, which at its trailing edge has flaps 14, 15 in order substantially to close the space below the wing 13 at the trailing edge, thereby preventing undesired loss of overpressure. As will be seen from Figure 4, the center of gravity 11 lies in front of the point of attack of the pressure force 13. The vehicle is balanced about the transversal axis due to the vertical component 16 of the engine thrust force 17.

As the vehicle picks up speed, the engines 9 are returned to a horizontal position as shown in Figure 5. The slip stream from the engines will then sweep along the upper side of the center wing, thereby assisting in producing the aerodynamic lift illustrated by the force arrow 18. Due to ground effect there will still be present a lift 13' on the lower side of the wing 3. This lift is, however, substantially reduced compared with the lift 13, and although there is now no longer any lift component 16 from the engine thrust force, the bow of the vehicle would lift except for the fact that there is an aerodynamic lift 19 from the side wings 4 and 5. In Figure 5 there is also indicated a small lift 20 from the canard wing 7.

In Figure 6 the variation of the lifts is shown diagrammatically as a function of the speed of the vehicle.

At low speed ordinary ailerons on the side wings 4 and 5 will not provide the desired effect. Instead, the flaps 14 and 15 may be used as ailerons at low speed, since the resulting lift force 13 may be shifted laterally by individual control of these flaps. The resulting difference in the frictional force on the hulls may in this connection make the vehicle turn. Furthermore, an ordinary rudder 26 may be used for turning at low speeds. A lower portion 26a of this rudder may be longitudinally split for simultaneous pivoting of the two parts of the rudder in opposite directions, whereby the water drag against the rudder is increased for turning the vehicle.

The vehicle according to the invention may be maintained in the position shown in Figure 4, in which merely the sharp keel portions 10 dip into the water, and in which the wing 3 as well as the engines 9 are postioned at a level above the water level corresponding to at least 1/3 of the centre wing chord, thus being protected against comparatively rough sea, even at very low speeds which may be required for manoeuvring in narrow waters.

Although the stability about the horizontal transversal axis of the vehicle in the transition phase between low and high speed can be cared for by controlling the inclination of the engines 9, this

method of control does not permit extremely rapid control movements, since this would create unfavourably high gyroforces. Thus, for a rapid control in connection with sudden influences, for instance from impacts of waves, especially during take off and landing when the speed is not particularly high, the vehicle according to the invention has special airfoil acting in connection with the slip stream from the fans or propellers. The positioning and function of this airfoil are illustrated in Figures 7 and 8. These Figures illustrate a turbofan engine, the fan 21 of which is surrounded by a shroud 22. Immediately behind the shroud and on the lower side thereof there is provided an airfoil 23 which is curved into a circular segment (see Figure 7). The airfoil 23 is positioned so that the air stream from the shroud 22 will touch the inner side of the curved airfoil 23. In the longitudinal direction the airfoil 23 has the profile of an airplane wing (see Figure 8), and the air stream from the shroud 22 as well as the air stream sucked into the gap 24 between the shroud 22 and the airfoil 23 will provide a substantial underpressure on the upper side of the airfoil 23, thereby providing a vertical lift on the airfoil. The airfoil 23 is pivotally mounted about a horizontal axis 25, and the lift on the airfoil will be strongly dependent upon the position of the airfoil. In this manner it is possible to obtain a lift force which can be varied very rapidly by pivoting the airfoil.

This principle may, of course, also be used as a rudder.

Figure 9 diagrammatically illustrates an alternative design of the bottom of the hull in which the depending keel portions are shaped as pivotal flaps 10', which may be folded up under the hull. The keel flaps 10' may be lockable in each extreme position. Furthermore, they may contain floats which assist in bracing them and at the same time provide a sufficient buoyancy in water for the keel flaps to swing up to folded position under the bottom of the hull when the vehicle floats in the sea.

The purpose of such a design is to allow the vehicle to enter shallow water.

As shown in Figure 9, wheels 27 may be mounted on the keel flaps 10', said wheels permitting wheeling of the vehicle on solid ground to facilitate pulling of the vehicle onto a slip or permit take off from dry land. Instead of wheels 27 there may also be provided runners, skis, or the like.

The keel flaps 10' may further be provided with longitudinal bracing ribs 28 which also assist in reducing leakage from the air cushion below the center wing laterally below the hulls, especially during take off from land. At the outer edge 29 the keel flaps 10' may be provided with a wear rim of a special type of plastic material having a low coeffisient of friction and a great strength. The leading edge of the keel flaps 10' may be shaped so as to contribute to swinging the flaps sidewards up under the hull when the keel flaps 10' move through water.

CLAIMS

1. Ground effect vehicle or aerofoil boat having two parallel hulls (1, 2), a center wing (3) connecting the two hulls, a forwardly open space being formed below the center wing between the hulls (1, 2), a tail structure connecting the hulls rearwardly of the center wing, and side wings (4, 5) positioned sufficiently far astern for their centers of lift to lie rearwardly of the center of lift of the center wing, due to an overpressure on the lower side thereof, characterized in

(a) that the center wing at its trailing edges has wing flaps (14, 15) which can close the space below the wing at the trailing edge, at least partially,

(b) that one or more engines (9) having an air propeller or a fan are positioned so as to direct the slip stream from the engines into said forwardly open space to provide an overpressure therein,

(c) that each hull (1, 2) is shaped with a sharp keel portion (10, 10') of a sufficiently large vertical extent to keep the said space closed laterally until the vehicle has picked up sufficient speed to provide a substantial aerodynamic lift on the center wing (3) as well as the side wings (4, 5), and

(d) that the side wings (4, 5) are positioned well above the water surface, so as to provide mainly aerodynamic lift and only a small ground effect.

2. Vehicle according to claim 1, characterized in that in connection with each fan or propeller engine (9) there is provided a curved airfoil (23) below the slip stream of the fan or propeller to induce a secondary air stream on the upper side of the airfoil and produce an upwardly directed aerodynamic force varying with the position of the airfoil with respect to the slip stream, so that the position of this airfoil (23) can be used to control the position of the vehicle about its horizontal transversal axis.

3. Vehicle according to claim 1 or 2, characterized in that the center wing (3) as well as the side wings (4, 5) have a distance from the water surface of at least 1/6 of the centre wing chord when the vehicle is floating on calm sea.

4. Vehicle according to any of the preceding claims, characterized in that the engine fans or propellers are positioned between the hulls (1, 2) forwardly of the center wing (3) and mounted so as to be tiltable about a horizonal transversal axis (8) from a position in which the slip stream from the engines is directed towards the forward opening into said forwardly open space to provide an overpressure therein, and in which the thrust force of the engines has a substantial upwardly directed component (16), to a position in which the slip stream sweeps along the upper side of the center wing (3) to increase the aerodynamic lift.

5. Vehicle according to claim 4, characterized in that the engine or engines (9) are mounted on a canard wing (7) which is provided between the front portions of the hulls (1, 2) and is tiltable about a horizontal transversal axis (6).

6. Vehicle according to any of the preceding claims, characterized in that the side wings (4, 5) are positioned on the outer side of each hull (1, 2).

7. Vehicle according to any of the preceding claims, characterized in that its center (11) of gravity is positioned forwardly of the center of lift of the center wing due to an overpressure on the lower side thereof, but rearwardly of its center of lift due to

an aerodynamic underpressure on the upper side.

8. Vehicle according to any of the preceding claims, characterized in that the submerged portion of each hull in the floating position is substantially symmetric about a longitudinal centre plane, apart from the sharp keel portion (10) which extends downwardly as an extension of the inner side of the hull.

9. Vehicle according to any of the preceding claims, characterized by the provision at the trailing end of the sharp keel portion (10) of a rudder (26a) that is longitudinally split for simultaneous pivoting of the two parts of the rudder in opposite directions, whereby the water drag against the rudder is increased for turning the vehicle.

10. Vehicle according to any of the preceding claims, characterized in that each keel portion (10') is pivotally hinged about a longitudinal horizontal axis for folding up when the vehicle is in a floating position.

11. Vehicle according to claim 10, characterized in that the keel portions (10') comprise floats for automatic folding up in water.

12. Vehicle according to claim 10 or 11, characterized in that the keel portions (10') are lockable in selected positions.

13. Vehicle according to any of the claims 10 to 12, characterized in that the pivotal keel portions (10') carry wheels (27) for wheeling the vehicle on solid ground when the keel portions are folded up.

14. A ground effect vehicle or aerofoil boat substantially as described with reference to the drawings.

Printed for Her Majesty's Stationery Office, by Croydon Printing Company Limited, Croydon, Surrey, 1983.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.